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The Abundances of the Elements
in Sharp Lined Early Type Stars

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General Remarks

This grant was to do archival work on IUE spectrograms of chemically peculiar stars. We have developed innovative methods to analyze these stars. The rationale and procedure is described below.

At the present time there is no generally accepted set of procedures for the synthesis of stellar spectra. Most workers in the field know generally what needs to be done. In many instances, current methods, which are based on automated equivalent width and curve of growth procedures, are adequate. We consider more complicated cases here, related to synthesis of the satellite ultraviolet, especially of chemically peculiar stars where the abundance patterns depart significantly from lockstep.

The density of atomic lines in the wavelength lists provided by R. L. Kurucz is now so high that some methods of filtering out irrelevant transitions was necessary. In addition, we felt it necessary to perfect *automatic* methods for line synthesis. In these methods, a the machine makes the required adjustments to the abundances necessary for optimum fits. This technique has several advantages over the commonly adopted trial-and-error method commonly in use. Obviously, machine fits can save time. Beyond this, the automatic fits do not incorporate the observer's unconscious prejudice of what the abundances ought to be!

This work has been done in collaboration with S. J. Adelman (The Citadel), D. S. Leckrone (Goddard), Scott Roby (U. Delaware-Oswego, NY), Glenn Wahlgren (Goddard-CSC). In several phases of the work, similar calculations were carried out independently by the various workers, and the results compared.

Developments During the Grant Period

Work on this project was begun in the summer of 1991 with the help of Federal Demonstration Project funds. Mrs. Bin Zhu was hired to run the programs and make improvements on them. In addition, Mr. Shimin Xu, Mrs. Zhu's husband, was able to make a number of changes that resulted in consistent convergence of the theoretical and calculated spectra. Mr. Xu is an advanced graduate student in the Michigan Department of Chemistry.

Abundances of roughly ten lines each of Ti II, Cr II, Mn II, Fe II, and Co II were calculated for the following seven stars: κ Cnc, o Peg, θ Leo, 21 Aql, π Cet, ν Cap, and HD 109995.

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The most elaborate calculations were done for Fe II. These calculations show that abundances can be obtained from IUE spectra that are in good agreement with those obtained from ground-based coude material. In addition, calculations based on the Michigan programs were in generally good agreement with those that used the Kurucz Atlas-Synthe routines. This is of significance because the Stark broadening routine used in our programs is completely independent of Kurucz's.

This work is currently being prepared for publication. Because it involves collaboration with several coworkers, progress has been slower than usual.

In collaboration with Andreas Redfors of Lund University, we have made calculations of abundances of yttrium and zirconium in three mercury-manganese stars using IUE spectra. For the first time it has been possible to base these determinations on the dominant ions, Y^{++} and Zr^{++}. Abundances of yttrium in a few of the mercury- manganese stars had been found so high that the abundances could not be explained by any conceivable nuclear mechanism. We had speculated that perhaps a breakdown of the ionization equilibrium caused the abundance to be overestimated when lines from the first ion were used. This problem could be eliminated by basing determinations on spectra from the dominant ion. Fortunately, Redfors (*Astron. Ap.* **249**, 589, 1991) had provided the necessary oscillator strengths.

We find, unexpectedly, that the dominant ions especially of yttrium, give higher abundances than the singly ionized species. There is apparently a breakdown of the Saha equation, but the deviation is in the opposite sense to that needed to produce a nuclear abundance pattern. This work has been submitted for publication jointly with Redfors to *Astronomy and Astrophysics*.